76th MORSS
10-12 JUNE 2008

MORS
Military Operations Research Society

CONTRACTOR DISCLOSURE FORM 712A

MORS P#: (if known) P-025-116

DEADLINE: 2 MAY 08
Fax to: 703-933-9066

PART I **Author Request** - The following author(s) request authority to disclose the following presentation at the next MORS Symposium with subsequent publication in the MORSS Final Report, for inclusion on the MORSS CD and/or posting on the MORS web site.

Principal Author: **Jeremy Eckhause**

Other Author(s): Robert Hemm, David Lee

Principal Author's **Organization and address:**
LMI
2000 Corporate Ridge McLean, Virginia 22102

Phone: (571) 633-7726
Fax: (703) 917-7519
Email: jeckhause@lmi.org

Principal Author's Signature and date: X 5/2/2008

Title of Presentation:
Blue SLAACM: A Stochastic Lanchester Campaign Model for Blue Attack

This presentation is believed to be: ☐ **SECRET** ☐ **CONFIDENTIAL** ☑ **UNCLASSIFIED** and will be presented in:

☐ **Special Session** ☐ **Tutorial** ☐ **Demo** ☐ **CG: A–B–C–D–E–F** (Circle one) ☑ **List all WG(s) #:** WG6, WG15, WG29B

This work was performed in connection with a government contract. ☑ **YES** (Complete Parts I, II, & III)

This presentation is based on material developed by the author as part of company-approved research e.g. IR&D. ☐ **YES** (Complete Parts I & III)

This presentation was NOT done under a government contract, contains no government information, is my own work and is approved for public release. ☐ **YES** (Complete Part I only)

PART II **Contractor Security Officer Endorsement** - The Contractor Security Officer concurs in the assigned classification and consents to the disclosure. A copy of the presentation, as made, will be provided to the Contracting Officer for approval.

This work was performed in connection with Contract #: W91QUZ-07-F-0076 let by (Activity): Defense Acquisition Agency ITEC4 Dated: 9/24/07

Contractor Security Officers Title: CSSO

Organization: LMI

Printed name: Grady W. McGuire

Complete mailing address: 2000 Corporate Ridge, McLean, VA 22102

X

Contractor Security Officer's Signature: Date:

Phone: 703-917-7050 FAX: 703-917-7324

PART III **Releasing Official/GOV'T Contracting Officer OR Study Sponsor** and DoD Directive 5230.24 – Required Applicable Distribution Statement

The Releasing Official/Government Contracting Officer or Study Sponsor, with the understanding that MORS Symposia are supervised by the OCNO N81, that all attendees have current security clearances of at least SECRET and that no foreign nationals will be present confirms that the overall classification of the presentation is:

☐ **SECRET** ☐ **CONFIDENTIAL** ☑ **UNCLASSIFIED** ☐ **OTHER:** _____ and authorizes disclosure at the meeting.

Classified by: Declassified by: Downgrade to: On:

☑ **Distribution statement A:** This presentation/paper is unclassified, approved for public release, distribution unlimited, and is exempt from U.S. export licensing and other export approvals under the International Traffic in Arms Regulations (22 CFR 120 et seq.)

☐ **Other distribution statement:** (List here or attach separate sheet)

Releasing Official/Gov't Contracting Officer or Study Sponsor's:

Title: Analyst

Name: Frank O. Lewis

Signature: X Frank O. Lewis

Organization: OSD / PA+E/TACAIR

Complete mailing address: Room 2C281, Pentagon, Washington DC 20301

Date: 05/02/2008 Email: Frank.Lewis2@osd.mil Phone: 703-695-2606 FAX: 703-697-7382

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
01 JUN 2008	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Blue SLAACM: a Stochastic Lanchester Air-to-Air Campaign Model for Blue Attack	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **LMI Mclean, VA 22102**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM202527. Military Operations Research Society Symposium (76th) Held in New London, Connecticut on June 10-12, 2008, The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**UU**	**23**	

LMI
GOVERNMENT CONSULTING
THE OPPORTUNITY TO MAKE A DIFFERENCE HAS NEVER BEEN GREATER

Blue SLAACM: a Stochastic Lanchester Air-to-Air Campaign Model for Blue Attack

Jeremy Eckhause, Robert Hemm, David Lee
in support of OD/PA&E TACAIR

MORS Symposium
June 10-12, 2008

Outline

- What is SLAACM?
  - “Air Defense” or “Classic” SLAACM
  - “Attack” or “Blue Attack” SLAACM
- SLAACM Features
  - Inputs & knobs
    - What the inputs reflect
    - What the knobs affect
  - Analysis protocol
  - Outputs
- Demo

SLAACM Summary

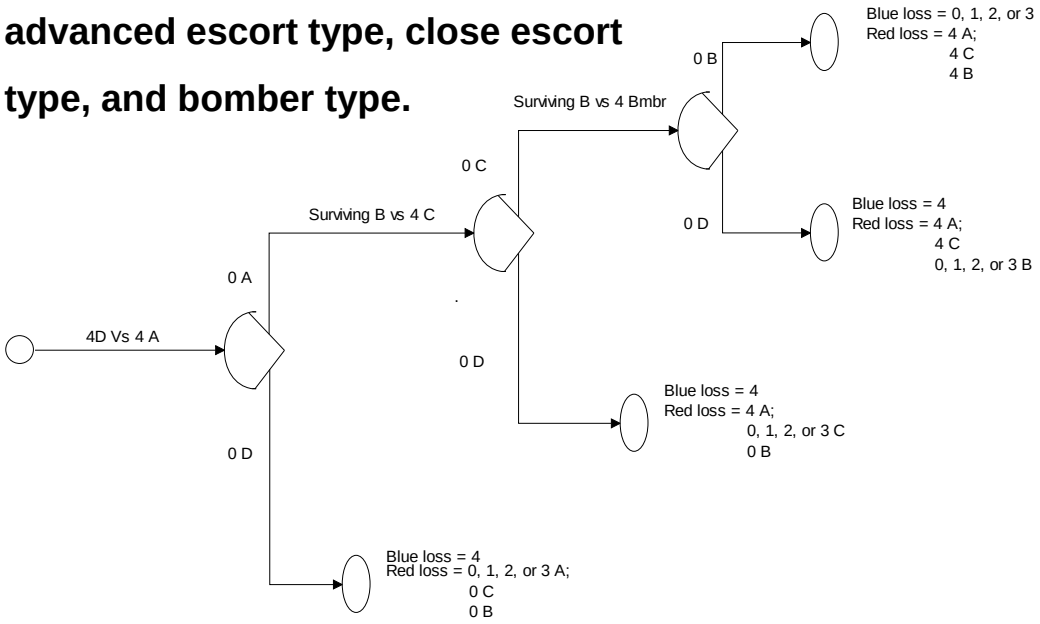
- The **S**tochastic **L**anchester **A**ir-to-**A**ir **C**ampaign **M**odel determines statistics of day-by-day attrition and destruction, for a two-sided campaign.
  - Each “day” the attacking side launches its forces in optimal attack packages.
  - Defensive counter-air forces respond. Certain defender aircraft respond with optimal sets of defending flights, while others encounter attack packages randomly and may encounter no opponents. Defender forces may include local air defenders, with different optimization rules from the other defense forces.
- SLAACM does not simulate; rather, it calculates engagement outcome statistics analytically, with parsimonious probabilistic models.

Campaign Analysis - Current Air Defense SLAACM Capabilities

- Extended list of Red and Blue aircraft options with calculation and use of full engagement statistics for all feasible attack and defense packages
- Integer programming optimization of Red attack and Blue defense that considers full engagement statistics
- Objective functions that include bomb effectiveness and user-adjustable aircraft kill and loss values
- Adjustable time phasing of Red and Blue supply to model attack and defense build-up
- Battle Management parameter to model AWACs impact
- Smart Blue optimization to model self-contained surveillance and battle management
- CAP factors to model remote basing
- Fully modeled classified scenarios

Air Defense SLAACM Scenario

Package type is triple [a, c, b], advanced escort type, close escort type, and bomber type.



Probabilities of these outcomes give Red and Blue loss distributions, and bombs delivered

Absorbing States

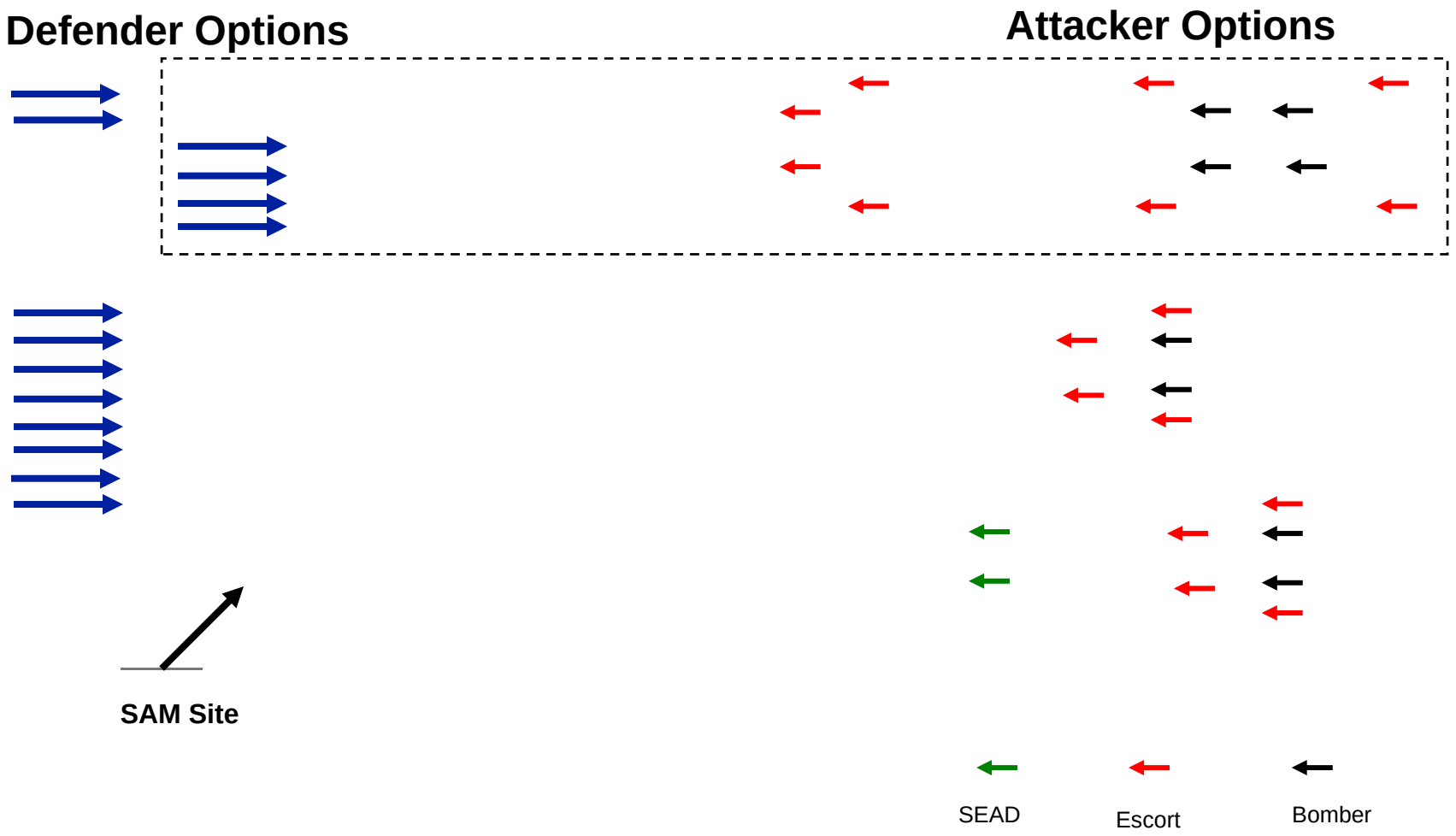
A	C	B	D
1	4	4	0
2	4	4	0
3	4	4	0
4	4	4	0
0	1	4	0
0	2	4	0
0	3	4	0
0	4	4	0
0	0	0	1
0	0	0	2
0	0	0	3
0	0	0	4
0	0	1	0
0	0	2	0
0	0	3	0
0	0	4	0

Calculations: 4 D vs 4 A; surviving D vs 4 C; surviving D vs 4 B

Attack (Blue) SLAACM Campaign Model Purpose and Features

- Extends bomber types include low observable aircraft
- Allows new multiple engagement scenarios including
  - Additional fighter defense M vs. N options
  - SEADs and SAMs
  - Stand-off jamming
- SLAACM software converted to object-oriented programming structure allowing flexible selection of
  - Attack package structure
  - Defender flight structure
  - Engagement model
  - Scenarios

Attack SLAACM Example Modules



Classic SLAACM Inputs

- Engagement Scenario
  - Attacker vs defender loss ratios
  - <mean time of Blue killing bomber>/<mean time bomber escape>
    - At user's choice, escaping bombers either abort or complete mission
  - Bomber payloads and delivery accuracies
  - Blue break point; Red break point
- Numbers of opposing forces
  - Includes day-by-day reinforcements
- CAP factor reflecting defenders flying combat air patrol
- Battle management factor reflecting C^4I effectiveness
  - "Smart" defenders do their own battle management
- Attacker value of defender loss, bomber mission, and attacker loss
- Defender value of attacker loss, bomber mission kill, and defender loss

Attack SLAACM Inputs

- Engagement Scenario
  - "Classic" Air Defense
  - SEAD
- Defense
  - 2, 4, or 8-ship defender flights
  - SAM/No SAM
- Engagement model
  - M-Vs-N probabilistic model with assigned breakpoints

Defense SLAACM feature Attack SLAACM feature

SLAACM's Analysis Protocol

- Calculate outcomes for all feasible engagements using a unique, fast algorithm.
- Calculate bomber effectiveness based on payload and CEP
- Use engagement outcomes and bomber effectiveness to generate attacker and defender payoff functions for optimizations
- Calculate optimal attacks and defenses using either a sorting heuristic or an integer programming solver
- Run campaign day-by-day and display results

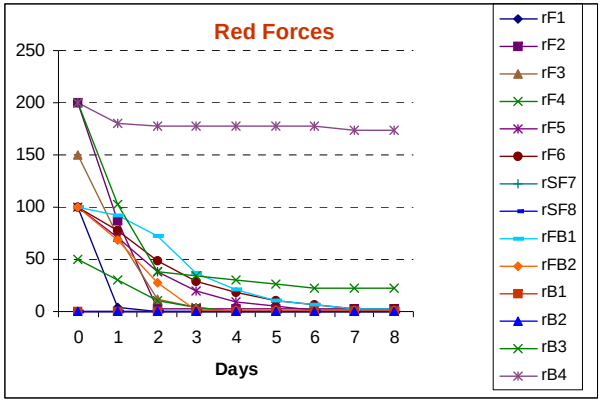
SLAACM Calculations

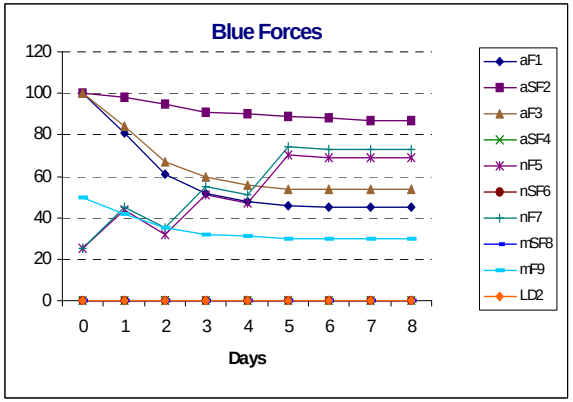
- Day-by-Day, solution of IP problem for Red's optimal attack
  - At user's choice, fast greedy heuristic or full IP solution
- Smart Blues mount optimized response
  - Other Blues encounter Red packages at random
- Full statistics of engagements calculated

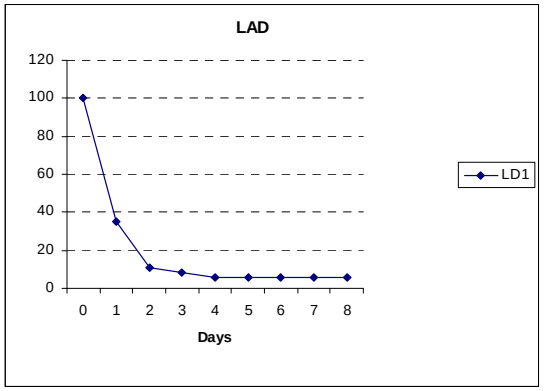
SLAACM Tabular Output

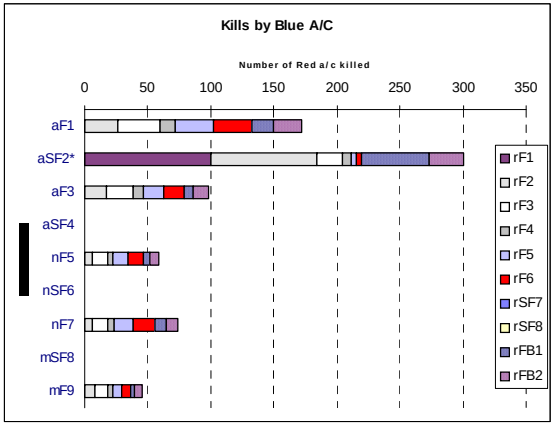
- Losses day-by-day
  - Central tendencies for Red and Blue
  - Dispersion measure for Blue
- “Who killed whom”
- Tons of bombs delivered day by day

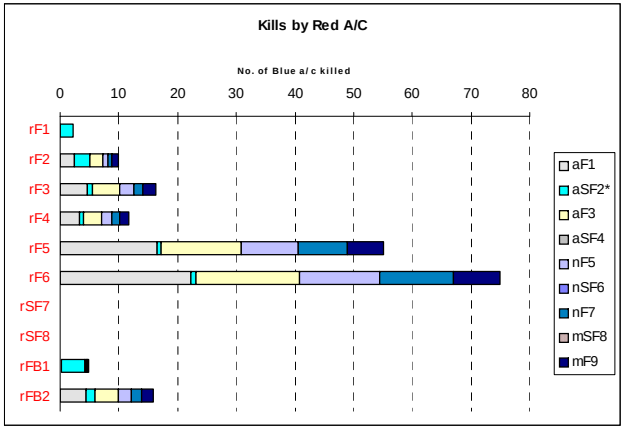
SLAACM Graphical Output

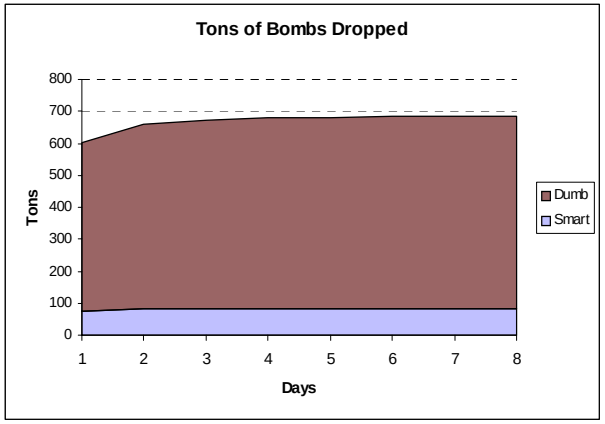












SLAACM Summary

- Air Defense SLAACM is a powerful, flexible analytical tool, that thoroughly meets all the requirements of a useful campaign model.
- Attack SLAACM has demonstrated the ability to analyze complex attack scenarios, and is far beyond Air Defense SLAACM in power and flexibility
- New software design supports the ultimate plan for an integrated defense/attack campaign optimization model that is fast, flexible, comprehensive, repeatable and traceable.

Demo

Attack SLAACM – Sample Scenario

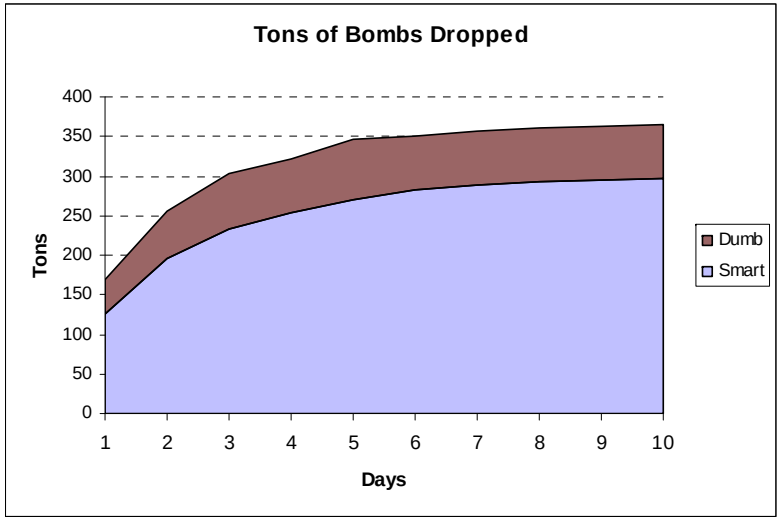
- Base Scenario
  - Attack Packages: 2 Bombers, 4 Escorts, 2 SEAD
  - Defense Packages: 8 Interceptors, 1 SAM site
    - SAM site engaged by SEADs; if survives, has time to fire 3 ready missiles while bombers in range
- Engagement Logic
  - Interceptors must defeat all escorts to attack bombers
  - SEADs engage SAMs in fight to death; SAMs only engage bombers if SEADs destroyed
  - Escorts and SAMs do not engage each other
  - Bombers escape interceptors based on a probability of escape-to-loss, rather than a kill-rate-ratio (but fighter-bombers fight)
  - Escaping bombers continue mission or abort; user choice

Attack Demo Campaign Scenario

- Order of Battle
  - Attacker types: 3 fighters, 1 SEAD, 3 fighter-bombers, 3 bombers
  - Defender types: 4 interceptors, 1 SAM site with 3 missiles
  - Time phasing of quantities: All available on first day (both sides)
  - CAP factors: 1 for all interceptors
- Rules of Engagement
  - Escaping bomber options: Bombers escape without dropping bombs
  - Battle management factor: 0.9
- Attacker and Defender Objective Function Coefficient Values
  - Attacker value of Attacker/Defender Loss: 2 / 20
  - Defender value of Defender/Attacker Loss: 5 / 20
- Campaign Duration – 10 days

Attack Demo Campaign Results

No SEAD

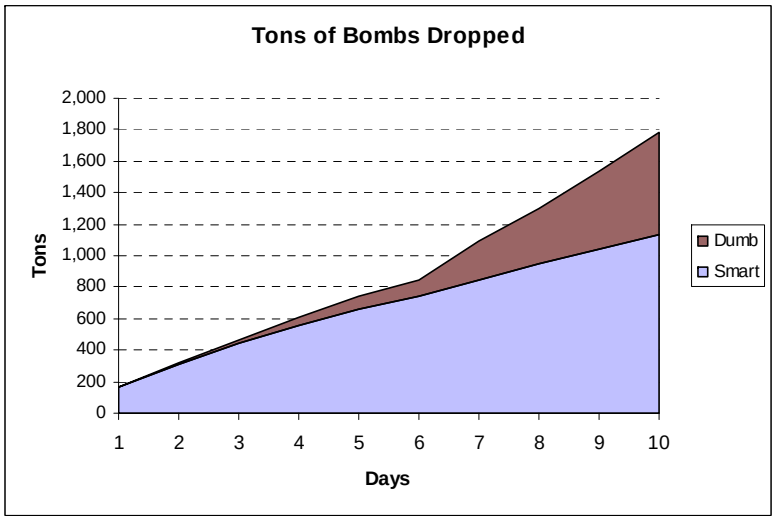


Totals (tons)

Dumb: 68

Smart: 296

SEAD



Totals (tons)

Dumb: 650

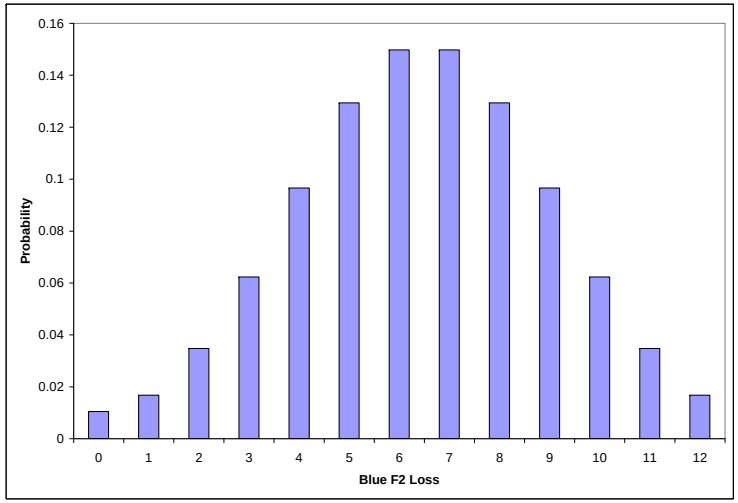
Smart: 1,138

Back-up

SLAACM gives dispersion as well as central tendency

Blue Losses

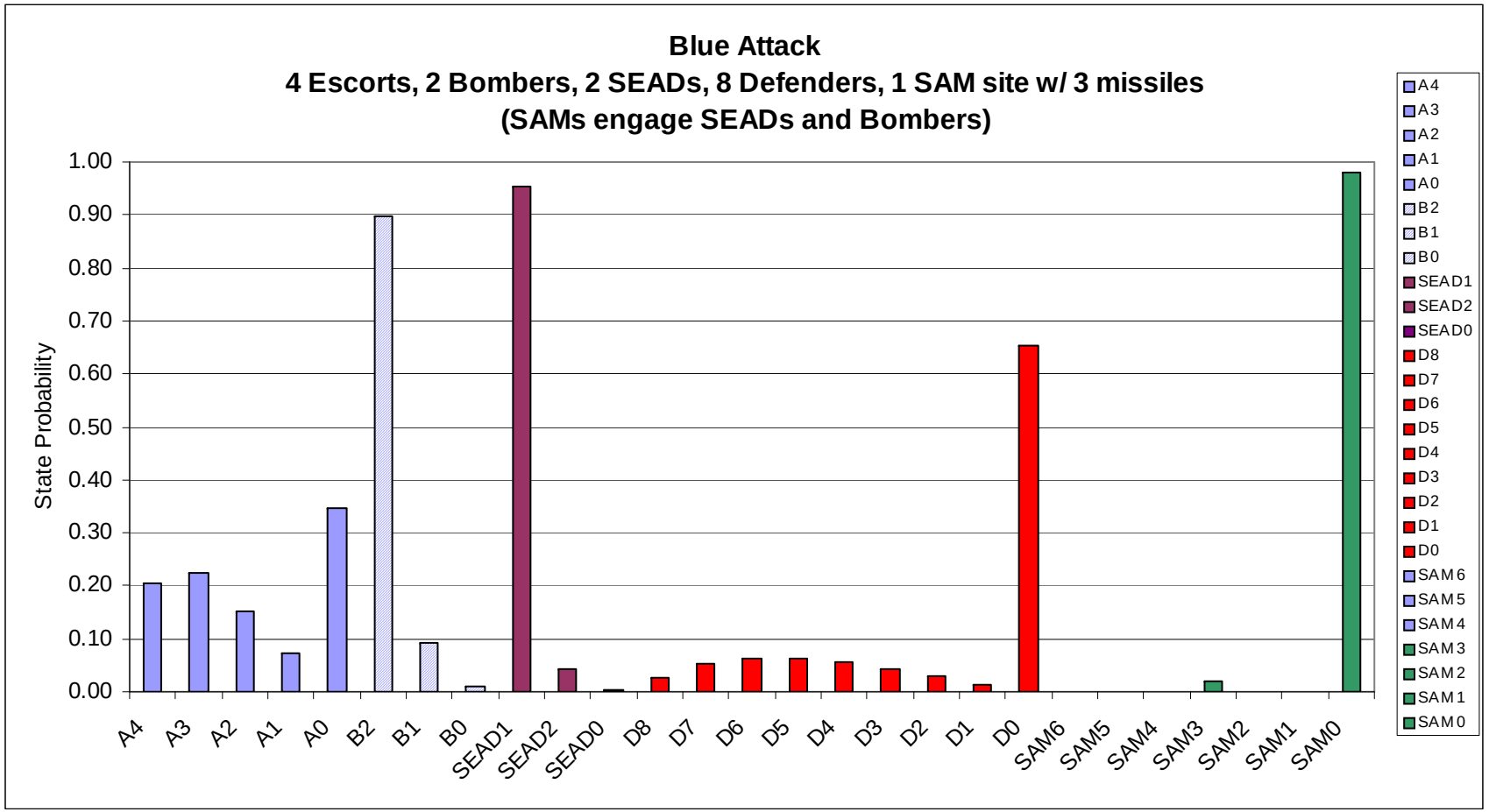
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total	Std. Dev.
aF1	8	9	8	3	1																29	6.09
aSF2	1	1	3	1	0																6	2.59
aF3	11	12	10	3	1																37	6.25
aSF4	0	0	0	0	0																0	0.00
nF5	4	8	7	4	1																24	5.04
nSF6	0	0	0	0	0																0	0.00
nF7	3	6	7	3	1																20	5.10
mSF8	0	0	0	0	0																0	0.00
mF9	5	5	5	1	0																16	4.27
LD1	49	29	11	1	0																90	8.12
LD2	0	0	0	0	0																0	0.00
																					0	0.00
																					0	0.00
																					0	0.00
																					0	0.00
																					0	0.00
																					0	0.00
																					0	0.00
																					0	0.00
TOTAL	81	70	51	16	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
cumulative	81	151	202	218	222	222	222	222	222	222	222	222	222	222	222	222	222	222	222	222		



21% probability that Blue F2 losses exceed 150% of mean value.

To estimate proportion of 20% with 1- or 2-point accuracy: 1600 runs.

Attack Engagement Example – 2 SEADs



Attack Engagement Example - 0 SEADs